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ORIGINAL RESEARCH ARTICLE

National Trends and Disparities in Hospitalization for Acute Hypertension Among Medicare Beneficiaries (1999–2019)

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BACKGROUND: In the past 2 decades, hypertension control in the US population has not improved and there are widening disparities. Little is known about progress in reducing hospitalizations for acute hypertension.

METHODS: We conducted serial cross-sectional analysis of Medicare fee-for-service beneficiaries age 65 years or older between 1999 and 2019 using Medicare denominator and inpatient files. We evaluated trends in national hospitalization rates for acute hypertension overall and by demographic and geographical subgroups. We identified all beneficiaries admitted with a primary discharge diagnosis of acute hypertension on the basis of International Classification of Diseases codes. We then used a mixed effects model with a Poisson link function and state-specific random intercepts, adjusting for age, sex, race and ethnicity, and dual-eligible status, to evaluate trends in hospitalizations.

RESULTS: The sample consisted of 397 238 individual Medicare fee-for-service beneficiaries. From 1999 through 2019, the annual hospitalization rates for acute hypertension increased significantly, from 51.5 to 125.9 per 100 000 beneficiary-years; the absolute increase was most pronounced among the following subgroups: adults ≥85 years (66.8–274.1), females (64.9–160.1), Black people (144.4–369.5), and Medicare/Medicaid insured (dual-eligible, 93.1–270.0). Across all subgroups, Black adults had the highest hospitalization rate in 2019, and there was a significant increase in the differences in hospitalizations between Black and White people from 1999 to 2019. Marked geographic variation was also present, with the highest hospitalization rates in the South. Among patients hospitalized for acute hypertension, the observed 30-day and 90-day all-cause mortality rates (95% CI) decreased from 2.6% (2.27–2.83) and 5.6% (5.18–5.99) to 1.7% (1.53–1.80) and 3.7% (3.45–3.84) and 30-day and 90-day all-cause readmission rates decreased from 15.7% (15.1–16.4) and 29.4% (28.6–30.2) to 11.8% (11.5–12.1) and 24.0% (23.5–24.6).

CONCLUSIONS: Among Medicare fee-for-service beneficiaries age 65 years or older, hospitalization rates for hypertensive emergencies increased substantially and significantly from 1999 to 2019. Black adults had the highest hospitalization rate in 2019 across age, sex, race and ethnicity, and dual-eligible strata. There was significant national variation, with the highest rates generally in the South.

Key Words: health equity ■ hypertension ■ mortality

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Clinical Perspective

What Is New?

- Among Medicare fee-for-service beneficiaries age 65 years or older, the hospitalization rate for acute hypertension increased more than double from 1999 to 2019.
- Racial and ethnic disparities in hospitalizations for acute hypertension widened from 1999 to 2019, with Black adults having the highest hospitalization rate in 2019 across age, sex, race and ethnicity, and dual-eligible strata.
- During the same period, the rates of 30-day and 90-day mortality and readmission among beneficiaries hospitalized for acute hypertension improved.

What Are the Clinical Implications?

- The marked increase in hospitalizations for acute hypertension raised concerns given the dramatic increase in health care costs.
- The lack of progress in reducing racial disparities in hospitalizations for acute hypertension highlights the need for new approaches to address both medical and nonmedical factors that contribute to such disparities.
- There has been progress in improving outcomes among patients hospitalized for acute hypertension; the issue is more about prevention of hospitalizations.

Nonstandard Abbreviations and Acronyms

AMI	acute myocardial infarction
CHF	congestive heart failure
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification

In recent decades, the United States has made little progress in hypertension control. Despite the availability of effective treatment and increase in hypertension diagnosis and awareness, national hypertension control (defined as blood pressure <140/90 mm Hg) has dropped from 54% in 2013–2014 to 44% in 2017–2018.[1] Given the growing prevalence and devastating effects of uncontrolled hypertension, the Surgeon General issued a call to action to make hypertension control a national priority.[2] A salient question is whether we have made any progress in preventing hospitalizations for acute severe hypertension, which are often associated with target organ damage and require urgent interventions.[3] It is also unknown whether there are differences in hospitalization trends by age, sex, race and ethnicity, and region over time.

Previous reports using data from the Nationwide Inpatient Sample and National Emergency Department Sample indicate that hospitalization rates for acute hypertension increased in the past decade[4–6]; however, these studies focused on short time frames, were not able to capture the entire nation's experience, did not assess demographic or geographic differences, and were not well positioned to assess trends attributable to sampling issues.[7] Thus, we lack a contemporary, comprehensive, national perspective on hospitalization trends for acute hypertension and associated outcomes, including readmission and mortality, and how they vary by demographic and geographical subgroups.

The Centers for Medicare & Medicaid Services is ideally positioned to provide information on trends in hospitalizations, mortality, and readmission outcomes nationally and by county. We studied all Medicare fee-for-service beneficiaries between 1999 and 2019 and evaluated hospitalization rates for acute hypertension and longer-term outcomes, including 30-day and 90-day readmission and mortality. Because substantial demographic and regional variation may exist in hypertension prevalence and outcomes, we evaluated rates of hospitalizations and associated outcomes by demographic subgroups and county.

METHODS

Study Population

All supporting data are available within the article and its online supplementary files. We identified all Medicare beneficiaries 65 years of age or older enrolled in the fee-for-service plan for at least 1 month from January 1999 to December 2019 using Medicare denominator files. For each year, we counted the total number of beneficiaries and calculated beneficiary-years to account for new enrollment, disenrollment, or death during the study period. We then linked beneficiary data with Medicare inpatient claims data to identify beneficiaries admitted with a primary discharge diagnosis of acute hypertension (ie, malignant hypertension, hypertensive heart disease, hypertensive renal disease, hypertensive emergency, hypertensive urgency, hypertensive crisis). Specifically, we adapted International Classification of Diseases, Ninth Revision, Clinical Modification data (ICD-9-CM codes 401.0, 402.0x, 403.0x, 404.0x, and 405.0x) from previous publications on a similar topic to identify hospitalizations for acute hypertension from January 1, 1999, to September 31, 2015.[4,5] The trends in hospitalizations for acute hypertension in this period were consistent with the published evidence. Because there was a transition from ICD-9-CM to ICD-10-CM codes on October 1, 2015, we converted the ICD-9-CM codes to corresponding ICD-10-CM codes (I100, I119, I110, I120, I132, I150, and I158) to identify hospitalizations for acute hypertension from October 1, 2015, to September 31, 2016. On October 1, 2016, the American Hospital Association Coding Clinic released new hypertension codes for hypertensive urgency, hypertensive emergency, and hypertensive crisis.[8] We adopted these new ICD-10-CM codes (I16.0, I16.1, I16.9) to identify hospitalizations for acute

hypertension from October 1, 2016 to December 31, 2019 (Table I in the Data Supplement). No marked change in hospitalization rate was observed when switching from ICD-9-CM to ICD-10-CM codes. Nevertheless, we reported the rates of hospitalizations on the basis of a 3-year interval to provide smoothed estimates over time.

Patient Characteristics

We determined the age, sex, and race and ethnicity (Asian, Black, Hispanic, North American Native, White, and Other) of beneficiaries and counted the number eligible for Medicaid for at least 1 month (dual-eligible) for the Medicare fee-for-service beneficiaries who were hospitalized for acute hypertension. The race variable was extracted from the Medicare enrollment database and originates from Social Security Administration records. We ascertained comorbidities from secondary diagnosis codes as well as from principal and secondary diagnosis codes from all hospitalizations for 12 months before the index hospitalization; data from 1998 were used for hospitalizations in 1999. These comorbidities were classified using the Hierarchical Condition Categories method.[9,10]

Outcomes

Our primary outcome was hospitalization for acute hypertension. Secondary outcomes were 30-day all-cause mortality, 30-day all-cause readmission, 30-day cause-specific readmission, 90-day all-cause mortality, 90-day all-cause readmission, and 90-day cause-specific readmission rates. We calculated hospitalization rates for acute hypertension by dividing the total numbers of acute hypertensive discharges in each year by the corresponding person-years of fee-for-service beneficiaries for that year.[11] To standardize the follow-up period, we used 30-day mortality rate, defined as the rate of deaths by all causes that occurred within 30 days from the date of admission of the index hospitalization for acute hypertension. We defined 30-day readmission as hospitalizations for all causes occurring within 30 days from the date of discharge from the index hospitalization, using November 30, 2019, as the final date of discharge for complete follow-up.[9–11] We also defined the condition-specific readmission rates for the principal discharge diagnoses of congestive heart failure (CHF), acute myocardial infarction (AMI), and stroke (see Table I in the Data Supplement for a list of ICD-9-CM and ICD-10-CM codes). The 90-day outcomes were defined similar to the 30-day outcomes, except we used September 30, 2019, as the final date for 90-day readmissions. If a patient had >1 hospitalization for acute hypertension during the study period, we counted them all for the hospitalization analysis but randomly selected 1 for the mortality and readmission analysis to minimize sample selection biases. The rationale was that if we chose the first hospitalization as the index hospitalization, we would bias the mortality rate to being lower and readmission rate to being higher or vice versa if we chose the last hospitalization.

Statistical Analysis

To facilitate data presentation, we divided the study period into 3-year intervals (1999–2001, 2002–2004, 2005–2007, 2008–2010, 2011–2013, 2014–2016, and 2017–2019) and compared patient characteristics between time interval,

demographic, and region (Northeast, South, West, Midwest, and others) subgroups. We expressed the hospitalization rates for acute hypertension as per 100 000 beneficiary-years and the rates of 30-day and 90-day all-cause mortality and readmission as percentages. To assess trends in rates of hospitalizations for acute hypertension, we fit a mixed effects model with a Poisson link function and state-specific random intercepts, adjusting for age, sex, dual-eligible status, and race and ethnicity. To assess trends in the rates of 30-day and 90-day mortality, we constructed a Cox proportional hazards regression to model mortality as a function of patient age, sex, dual-eligible status, race and ethnicity, and comorbidity. We repeated this model for 30-day and 90-day readmission. Patients who switched to the Medicare Advantage plan after the initial hospitalization for acute hypertension were treated as lost to follow-up and deaths before a readmission were accounted for using the Fine and Gray method[12] for competing risks. We checked the adequacy of the Cox regression model and found that the proportional hazards assumption was satisfied.[13] For all models, time was modeled as an ordinal variable, corresponding to the years 1999 (time=0) to 2019 (time=20), to represent the adjusted annual percent change in each outcome. We repeated models for age, sex, race, and dual-eligible status subgroups.

To assess geographic trends and variation in hospitalizations, we extended the Centers for Medicare & Medicaid Services model used for profiling hospital performance on outcomes[13] with a Poisson link function to model the number of hospitalizations for acute hypertension as a function of patients' age, sex, dual-eligible status, and race and ethnicity. We then calculated a risk-standardized number of hospitalizations per 100 000 beneficiary-years for each county and the beginning (1999–2001) and ending (2017–2019) study periods. We mapped counties using a gradient from red, yellow, and green (increase in red, on average in yellow, and decrease in green).[14,15] We also calculated a Pearson correlation coefficient between the 1999 to 2001 and 2017 to 2019 periods to evaluate the change in hospitalizations geographically. We hypothesized that the increase in hospitalization rates was nationwide, regardless of the individual county's baseline rate. Because there were no specific ICD-10-CM codes for hypertensive emergency, hypertension urgency, or hypertension crisis during the period of October 1, 2015, through September 31, 2016, we conducted a sensitivity analysis that excluded patients hospitalized during this period to address this potential bias in study sample.

All analyses were conducted using SAS version 9.4 (SAS Institute Inc). All statistical testing was 2-sided at a significance level of 0.05. Institutional review board approval for this study was obtained through the Yale University Human Investigation Committee and informed consent was waived. The study followed the guidelines for cohort studies described in the Strengthening the Reporting of Observational Studies in Epidemiology.[16]

RESULTS

Patient Characteristics and Comorbidities

The study sample consisted of 449 865 acute hypertensive discharges (ie, malignant hypertension, hypertensive heart disease, hypertensive renal disease, hypertensive

emergency, hypertensive urgency, hypertensive crisis) and represented 397 238 unique beneficiaries 65 years or older with ≥1 month of enrollment in the Medicare fee-for-service plan during the 21-year study period. Between 1999 to 2001 and 2017 to 2019, the average age of patients increased slightly (76.7 years [SD 7.4] versus 77.9 years [SD 8.7]), the proportion of female patients declined from 74.9% to 68.7%, the percentage of White patients decreased from 74.9% to 70.7%, and the percentage of Black patients increased from 20.3% to 21.3%. Several comorbidities were more commonly coded in 2017– 2019 (Table), including renal failure (10.7% in 1999–2001 versus 38.6% in 2017–2019), respiratory failure (2.5% in 1999–2001 versus 7.5% in 2017–2019), and diabetes (29.6% in 1999–2001 versus 39.2% in 2017–2019). All P values were <0.001 for trend. The changes in patient baseline characteristics by demographic and region subgroups are shown in Tables II–VI in the Data Supplement.

Trends in Hospitalization for Acute Hypertension Overall and by Demographic Subgroups

Between 1999 and 2019, the observed rate of hospitalization for acute hypertension among Medicare fee-for-service beneficiaries increased significantly from 51.5 to 125.9 per 100 000 beneficiary-years (Figure 1). Among Medicare beneficiaries, the absolute increase in hospitalizations for acute hypertension was most pronounced among those who were ≥85 years of age (66.8–274.1), females (64.9–160.1), Black people (144.4–369.5), and dual-eligible people (93.1–270.0; Figure 1). Across all age, sex, race and ethnicity, and dual-eligible strata, differences by race and ethnicity in hospitalizations for acute hypertension increased substantially, with a rate of 369.5 per 100 000 beneficiary-years among Black beneficiaries compared with 171.1, 147.8, 109.0, and 104.8 per 100 000 beneficiary-years among Hispanic, North American Native, Asian, and White beneficiaries in 2017–2019, respectively. These findings did not change substantially after adjusting for beneficiaries' demographic characteristics. After adjusting for age, sex, race and ethnicity, and dual-eligible status, the overall annual hospitalization rate for acute hypertension increased by 5.64% (95% CI, 4.89–6.39). The annual increased rates among Asian (8.21% [5.76–10.72]), Black (6.00% [5.02–6.99]), Hispanic (8.54% [6.64–10.47]), and North American Native (9.94% [7.91–12.01]) beneficiaries was more pronounced than in White beneficiaries (5.42% [4.75–6.09]; Figure I in the Data Supplement). Compared with White beneficiaries, Black beneficiaries had 2.59 (2.41–2.77) times higher hospitalization rate for acute hypertension in 1999–2001 and 3.07 (2.86–3.30) times higher rate in 2017–2019 (Figure II in the Data Supplement); Hispanic and North American Native

beneficiaries had similar hospitalization rates in 1999–2001 (incidence rate ratio 0.80 [0.64–1.01] and 0.61 [0.25–1.41], respectively), but significantly higher rates (incidence rate ratio 1.18 [1.00–1.40] and 1.44 [1.18–1.78]) in 2017–2019. Asian beneficiaries had lower hospitalization rate for acute hypertension in 1999–2001 (incidence rate ratio 0.57 [0.33–0.96]), but this difference decreased in 2017–2019 (incidence rate ratio 0.77 [0.67–0.89]). The sensitivity analysis, which excluded patients who were hospitalized during the period from October 1, 2015, through September 31, 2016, showed similar results (Figures III and IV in the Data Supplement).

Geographical Variation in Hospitalization for Acute Hypertension

We observed marked geographic variation in hospitalization rates for acute hypertension at the county level, with higher rates in the South in 1999–2001 (Figure 2A); this was moderately persistent in 2017–2019 (Figure 2B). The Pearson correlation coefficient of county-specific hospitalization rates between 1999–2001 and 2017–2019 was 0.34 (95% CI, 0.30–0.37), indicating that the increase in hospitalization rates was nationwide and not strongly associated with counties' baseline rates. The increase in hospitalization rates over the study period was observed geographically. Among 3143 counties and county equivalents included in the study, <1% of counties had no change (n=7) or decreased (n=20) hospitalization rates and the majority of counties (n=3116) had increased hospitalization rates (Figure 2C).

Trends in Mortality and Readmission Rates Among Hospitalized Patients

Among beneficiaries hospitalized for acute hypertension, the observed 30-day and 90-day all-cause mortality decreased from 2.6% (2.27–2.83) and 5.6% (5.18–5.99) in 1999–2001 to 1.7% (1.53–1.80) and 3.7% (3.45–3.84) in 2017–2019, and the observed 30-day and 90-day all-cause readmission decreased from 15.7% (15.1–16.4) and 29.4% (28.6–30.2) to 11.8% (11.5–12.1) and 24.0% (23.5–24.6), respectively. No significant change was found in the rates of 30-day readmission for AMI (0.4% [0.31–0.54] in 1999–2001 and 0.4% [0.30–0.43] in 2017–2019), but a significant decrease in 90-day readmission (1.2% [0.96–1.35] in 1999–2001 and 0.9% [0.74–0.96] in 2017–2019) was noted. A marked decrease was observed in the 30-day and 90-day readmission rates for CHF from 2.5% (2.25–2.82) and 5.8% (5.40-6.25) to 1.5% (1.42–1.68) and 3.7% (3.42–3.89), in the rates for stroke from 0.8% (0.62–0.93) and 1.9% (1.67–2.17) to 0.5% (0.46–0.61) and 1.1% (0.95–1.20), and in the rates for AMI/CHF/stroke combined from 5.2% (4.78–5.58) and 11.8% (11.3–12.4) to 3.8% (3.57–3.97) and 8.8% (8.40–9.09), respectively.

Table. Characteristics of Patients Hospitalized for Acute Hypertension (1999–2019)

Patient characteristics	Patients, n (%)						
	1999–2001	2002–2004	2005–2007	2008–2010	2011–2013	2014–2016	2017–2019
Patients, n	38 181	27 425	39 117	43 858	55 931	94 633	98 093
Demographics							
Age, y, mean (SD)	76.7 (7.4)	77.1 (7.6)	77.3 (7.7)	77.7 (8.0)	77.9 (8.3)	77.5 (8.5)	77.9 (8.7)
Women	28 582 (74.9)	20 501 (74.8)	28 479 (72.8)	31 706 (72.3)	39 824 (71.2)	60 932 (64.4)	67 399 (68.7)
White	28 594 (74.9)	20 025 (73.0)	27 833 (71.2)	30 684 (70.0)	38 657 (69.1)	63 564 (67.2)	69 340 (70.7)
Black	7747 (20.3)	5893 (21.5)	9139 (23.4)	10 579 (24.1)	13 579 (24.3)	23 416 (24.7)	20 903 (21.3)
Hispanic	620 (1.6)	548 (2.0)	832 (2.1)	1009 (2.3)	1534 (2.7)	2905 (3.1)	2563 (2.6)
Asian	332 (0.9)	306 (1.1)	481 (1.2)	670 (1.5)	1000 (1.8)	2098 (2.2)	2077 (2.1)
North American native	43 (0.1)	60 (0.2)	111 (0.3)	147 (0.3)	204 (0.4)	510 (0.5)	572 (0.6)
Other races	845 (2.2)	593 (2.2)	721 (1.8)	769 (1.8)	957 (1.7)	2140 (2.3)	2638 (2.7)
Dual eligible	8655 (22.7)	6586 (24.0)	9556 (24.4)	10 854 (24.7)	14 416 (25.8)	24 847 (26.3)	21 915 (22.3)
Cardiovascular risk factors and conditions							
Diabetes	11 315 (29.6)	8607 (31.4)	13 182 (33.7)	15 935 (36.3)	21 860 (39.1)	42 829 (45.3)	38 444 (39.2)
Renal failure	4071 (10.7)	3298 (12.0)	7775 (19.9)	17 103 (39.0)	23 708 (42.4)	51 056 (54.0)	37 852 (38.6)
Atherosclerotic disease	14 267 (37.4)	10 770 (39.3)	15 778 (40.3)	17 966 (41.0)	22 585 (40.4)	36 571 (38.6)	32 313 (32.9)
Unstable angina	1912 (5.0)	1178 (4.3)	1517 (3.9)	1345 (3.1)	1475 (2.6)	3199 (3.4)	3223 (3.3)
Previous myocardial infarction	1251 (3.3)	897 (3.3)	1393 (3.6)	1756 (4.0)	2198 (3.9)	4984 (5.3)	3516 (3.6)
Previous heart failure	6350 (16.6)	4679 (17.1)	7326 (18.7)	8547 (19.5)	10 542 (18.8)	24 928 (26.3)	14 719 (15.0)
Peripheral vascular disease	4401 (11.5)	3306 (12.1)	5111 (13.1)	5879 (13.4)	7110 (12.7)	13 196 (13.9)	9088 (9.3)
Previous stroke	1352 (3.5)	1004 (3.7)	1294 (3.3)	1428 (3.3)	1814 (3.2)	3023 (3.2)	3122 (3.2)
Cerebral vascular disease other than stroke	4734 (12.4)	3407 (12.4)	4649 (11.9)	5150 (11.7)	6915 (12.4)	10 185 (10.8)	12 509 (12.8)
Other conditions							
Chronic obstructive pulmonary disease	6295 (16.5)	4782 (17.4)	7426 (19.0)	8193 (18.7)	9997 (17.9)	19 563 (20.7)	15 120 (15.4)
Pneumonia	2783 (7.3)	2172 (7.9)	3495 (8.9)	4551 (10.4)	6174 (11.0)	15 035 (15.9)	8726 (8.9)
Respiratory failure	955 (2.5)	701 (2.6)	1331 (3.4)	2328 (5.3)	3503 (6.3)	11 113 (11.7)	7390 (7.5)
Liver disease	841 (2.2)	702 (2.6)	1062 (2.7)	1304 (3.0)	1757 (3.1)	4207 (4.4)	3445 (3.5)
Cancer	1948 (5.1)	1488 (5.4)	2179 (5.6)	2534 (5.8)	3138 (5.6)	6012 (6.4)	5729 (5.8)
Depression	2765 (7.2)	2405 (8.8)	3480 (8.9)	4012 (9.1)	5216 (9.3)	8428 (8.9)	9330 (9.5)
Other major psychiatric disorders	1116 (2.9)	854 (3.1)	1246 (3.2)	1474 (3.4)	2167 (3.9)	3414 (3.6)	3346 (3.4)
Trauma in past year	2049 (5.4)	1613 (5.9)	2595 (6.6)	2933 (6.7)	3663 (6.5)	6227 (6.6)	5878 (6.0)

These trends were similar among all age, sex, race and ethnicity, and dual-eligible status strata (Figure 3). After accounting for patient characteristics, the adjusted annual decreases in rates for 30-day all-cause mortality, all-cause readmission, CHF-specific, AMI-specific, stroke-specific, and AMI/CHF/stroke readmissions were 2.0% (1.95–2.12), 2.3% (2.17–2.37), 2.1% (1.97–2.15), 2.0% (1.87–2.04), 2.0% (1.88–2.05), and 2.1% (2.00–2.18), respectively. The adjusted annual decreases in rates for 90-day all-cause mortality, all-cause readmission, CHF-specific, AMI-specific, stroke-specific, and AMI/CHF/stroke readmissions were 2.1% (2.02–2.20), 2.3% (2.17–2.38), 2.1% (2.00–2.19), 1.9% (1.83–2.02), 2.0% (1.87–2.05), and 2.1% (2.04–2.23), respectively. Compared with White beneficiaries, Black beneficiaries had consistently higher rates of all 30-day and 90-day

mortality and readmission outcomes in 1999 to 2001, but similar rates of these outcomes in 2017 to 2019 (Figure II in the Data Supplement). Asian, Hispanic, and North American Native beneficiaries had similar rates of mortality and readmission outcomes compared with White beneficiaries in both 1999 to 2001 and 2017 to 2019. The sensitivity analysis, which excluded patients who were hospitalized during the period from October 1, 2015, through September 31, 2016, showed similar results (Figures III and IV in the Data Supplement).

DISCUSSION

In this comprehensive analysis of hospitalization trends in the Medicare fee-for-service population age 65 years or older, we found a marked increase in hospitalization
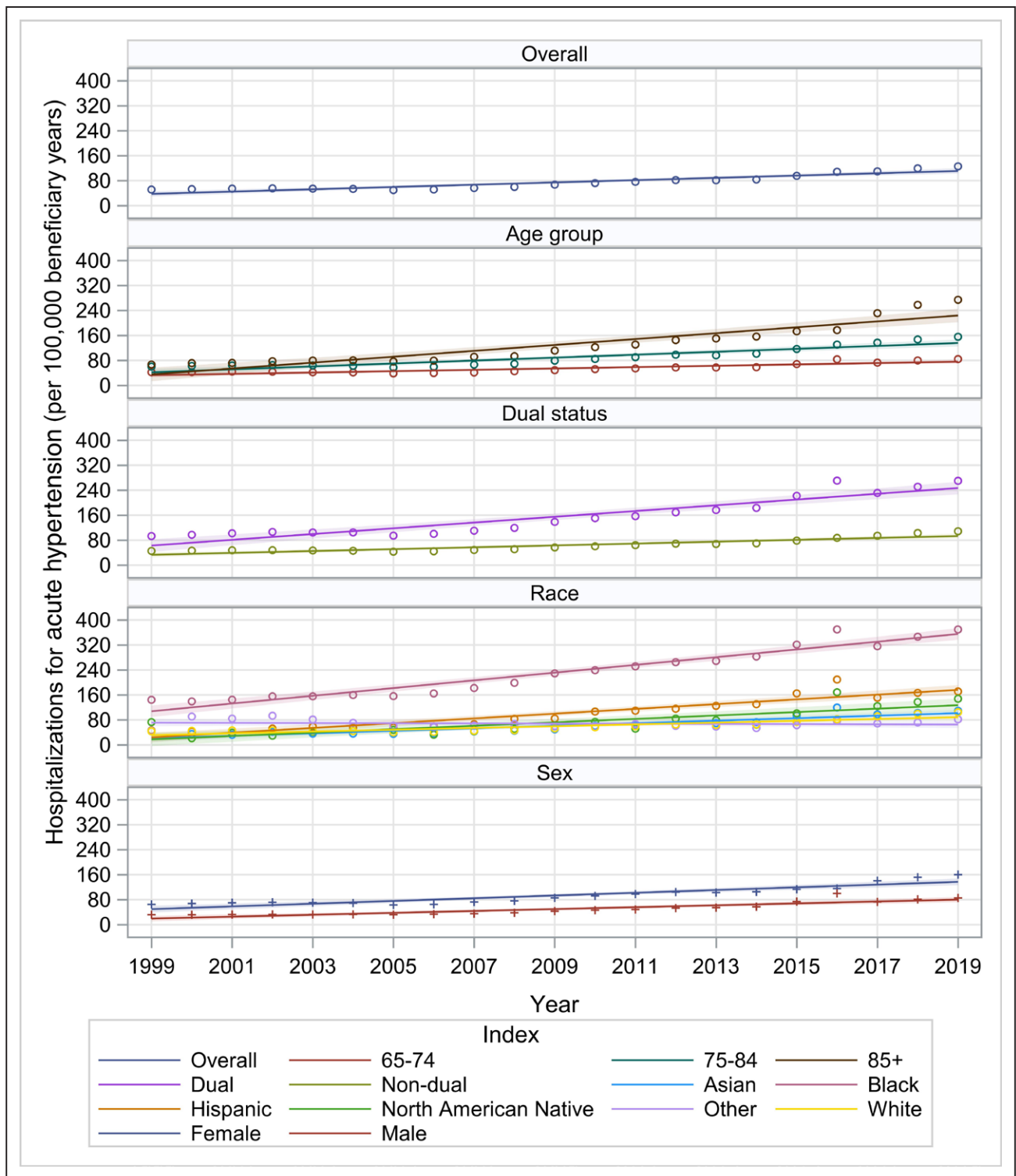
Figure 1. Observed trends in hospitalization rate for acute hypertension in the Medicare fee-for-service population, overall and by age, sex, race, and dual-eligible status (1999–2019).

for acute hypertension between 1999 and 2019. The absolute increase was most pronounced among Medicare beneficiaries who were Black, age >85 years, women, and dual-eligible, with Black beneficiaries having the largest 20-year increase across all age, sex, race and ethnicity, and dual-eligible strata. This overall trend was consistent nationwide, although geographic variation was present. Counties in the South[17] had the highest rate of hospitalizations.

This study adds to the literature in several ways. It is the most contemporary study of the Medicare fee-for-service population and provides direct evidence of the
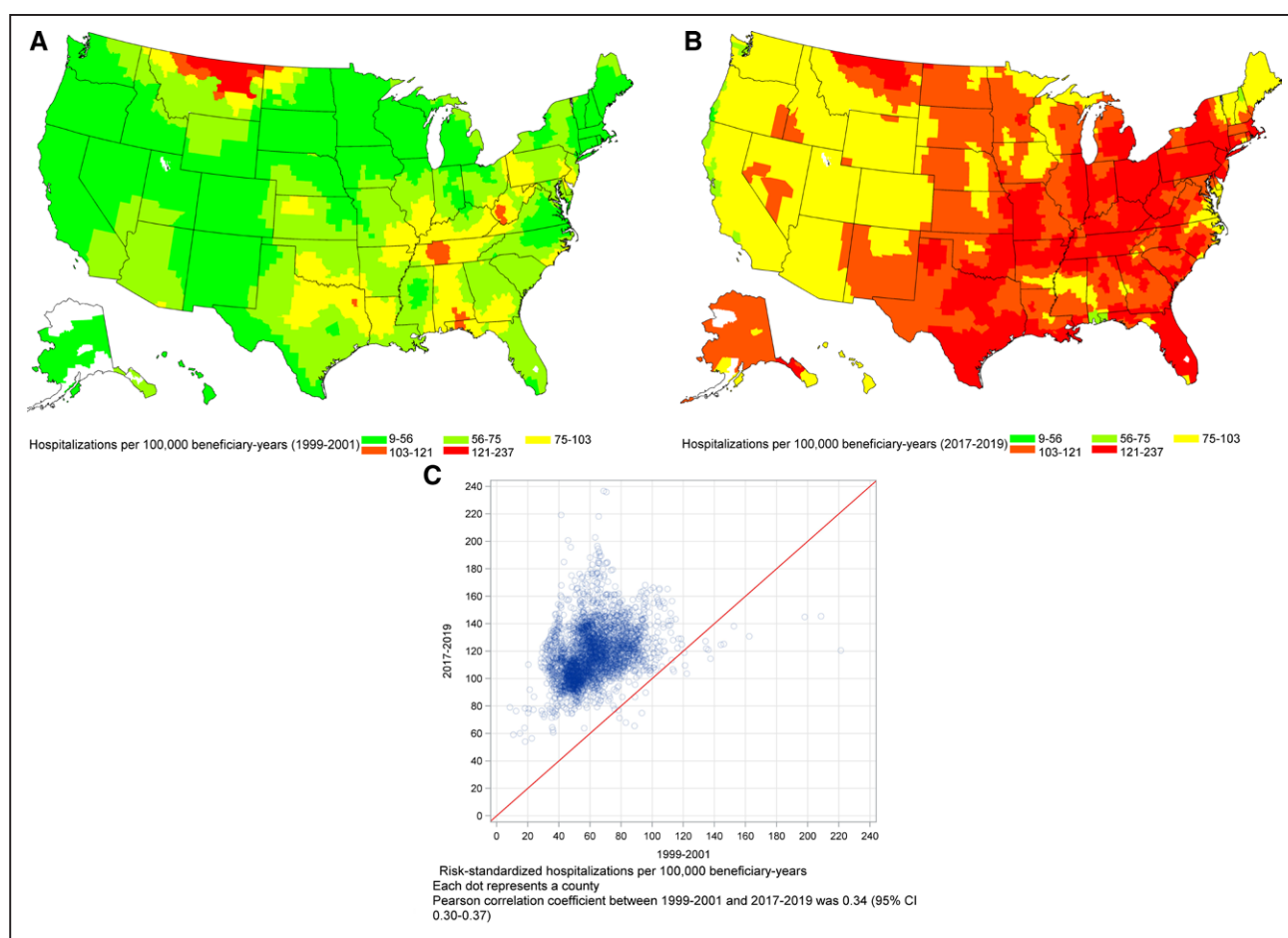
Figure 2. Maps showing trends in risk-standardized hospitalization rate for acute hypertension in the Medicare fee-for-service population for individual US counties (1999–2019).
A, Risk-standardized hospitalization rate for acute hypertension for individual US counties (1999–2001). **B**, Risk-standardized hospitalization rate for acute hypertension for individual US counties (2017–2019). **C**, Correlation between risk-standardized hospitalization rate for acute hypertension for individual US counties in 1999 to 2001 and 2017 to 2019.

failure of clinical and public health interventions in reducing the risk of hospitalizations for acute hypertension. The findings are concordant with evidence that age-adjusted mortality from hypertension is rising, stroke rates are rising, and hypertension control is declining. Black beneficiaries have the highest rates of hospitalizations for acute hypertension with the steepest increase in rates. Previous studies,[4–6] with different analyses that used National Inpatient Sample data from 2000 to 2012, have showed results that were broadly consistent even as they focused on shorter time frames and did not examine variations by population subgroups.

Because the study uses administrative codes, it is important to consider whether the observed trend may be attributable to changes in coding or admission practices. Polgreen and colleagues[6] hypothesized that a shift toward assigning more severe diagnoses in administrative billing codes might have accounted for the increased hospitalizations for acute hypertension. However, the study by Polgreen et al.[6] used data before 2011 and

we also observed a marked increase in hospitalization for acute hypertension after 2011. The changes were large and progressive; there was no discontinuity in the trend. It seems unlikely that coding shifts could have accounted for the marked changes over the 20-year period. Moreover, there was no changing financial incentive over time or any national effort to focus attention on greater recognition of this cause of admission over the study period. This observation is also unlikely to be a result of a changing admission threshold. Studies suggest that the admission thresholds for chronic conditions like hypertension may have increased, with patients with more severe cases being admitted and many patients with less severe cases being treated as outpatients.[18,19] This finding is supported by the increasing trend of baseline comorbidities among patients hospitalized for acute hypertension in our study. Moreover, even if there has been some systematic change in admission criteria, it is unlikely this would explain the greater disparities among certain demographic subgroups, because we

would expect any effect in coding or admission to affect all groups. The most likely explanation for our findings is that there has been a real increase in hospitalizations and that there are disparities by various groups. Our findings are consistent with (and markedly extend) recent studies of hypertensive heart disease mortality, stroke mortality, and hypertension control. During the study period, the hypertensive disease mortality rate among US adults 65 years and older increased from 98.4 in 1999 to 140.0 per 100000 population in 2018.[20,21] Ischemic stroke−related mortality rates declined from 1999 to 2011, and then markedly increased from 2012 to 2018. Hypertension control rate among US adults 65 years and older decreased from 54.1% in 2013 to 44.5% in 2018.[1] This consistent evidence suggests that the marked increase in hospitalization for acute hypertension, especially while health care costs are rising, are of great concern. There was an increasing trend in baseline comorbidities including diabetes and renal failure during the same period among patients hospitalized, which could in part contribute to the increase in hospitalizations for acute hypertension. This is supported by published evidence of the increasing trend in diabetes and end-stage renal disease in the Medicare population.[22–24] Beneficiaries who had hypertension concurrent with diabetes and renal failure are more likely to be admitted to the hospital.

A striking finding of this study was highlighted by the rapid increase in racial disparities of hospitalization for acute hypertension between Black and White beneficiaries, with Black people consistently having higher rates during the past 20 years. Stratification by age, sex, and dual-eligible status showed persistent racial differences across strata. Such findings are especially important given that hypertension disproportionally affects Black people. Compared with White people, hypertension in Black people occurs at an earlier age, is more severe, and is more likely to be associated with end-organ damage.[25,26] We demonstrated worsening health inequities with respect to hospitalization for acute hypertension, despite the improvement in mortality and readmission outcomes among those hospitalized. Given the significant health care investments and dramatic increases in per capita health care costs,[27,28] the lack of progress in reducing racial disparities in hospitalizations for acute hypertension highlights the need for new approaches to address both medical and nonmedical factors that contribute to such disparities, including systemic racism,[29–33] poor hypertension control,[34–36] and high prevalence of renal diseases[37,38] among Black individuals.

Our study evaluates several longer-term outcomes after hospitalization for acute hypertension that have not been studied in a national cohort. We showed improved mortality and readmission rates among those hospitalized and these improvements were consistent across age, sex, race, and dual-eligible subgroups. These improvements may, in part, be associated with national efforts to improve the care of all patients across the study period.[39–44] Studies have showed improvements in process measures and outcomes for many conditions in Medicare beneficiaries.[14,15,45] Improvements in outcomes observed may have been related to advances in treatments and health technologies. For example, the use of statins for prevention, the expansion of coronary revascularization, and the improvement in use of evidence-based medications are likely contributing to a lower risk of repeat hospitalization and improved survival associated with cardiovascular diseases.[46–48] These results suggest that we have made progress in improving outcomes once patients are hospitalized for an acute illness; the issue is more about preventing hospitalizations for acute hypertension.
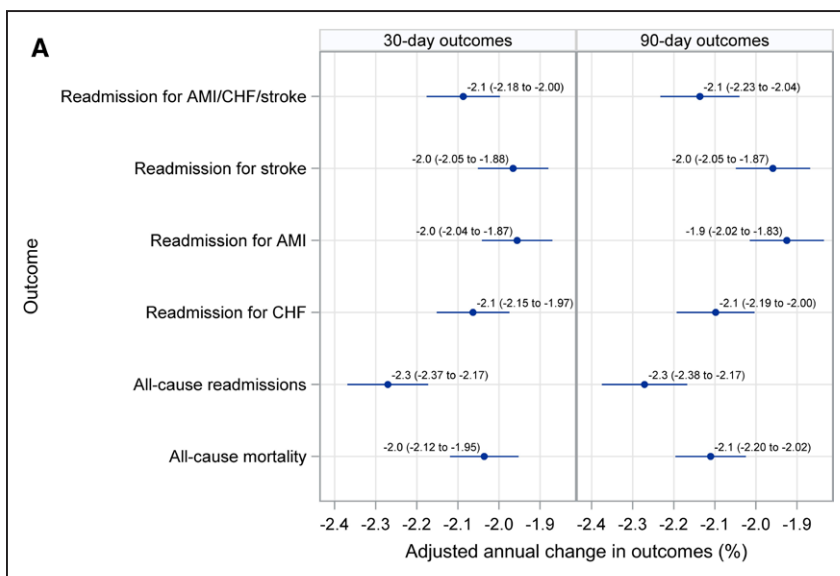

Figure 3. Adjusted annual change in 30-day and 90-day mortality and readmission rates, overall and by subgroups.
A, Adjusted annual change in 30-day and 90-day mortality and readmission rates for the overall study population. **B**, Adjusted annual change in 30-day and 90-day mortality and readmission rates by age, sex, race, and dual-eligible status subgroups. AMI indicates acute myocardial infarction; and CHF, congestive heart failure (Continued).

Figure 3. Continued
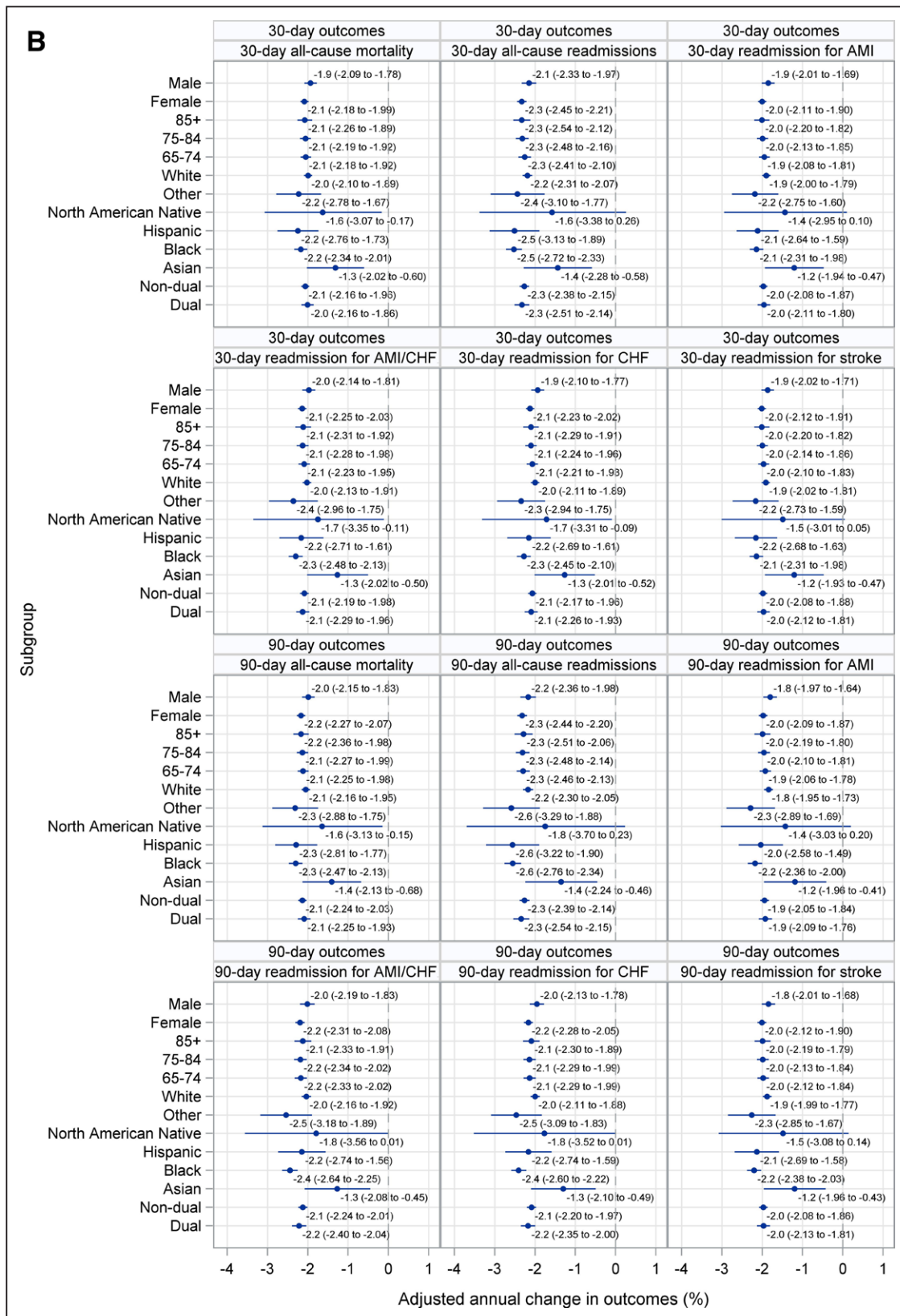
Limitations

This study has several limitations. First, we studied only Medicare fee-for-service beneficiaries and the results in this elderly population may not be fully generalizable to the broader US national population. However, this database represents the most complete national data for assessing rate of hospitalizations and long-term outcomes. Second, we used administrative claims to identify hospitalizations for acute hypertension. We did not have blood pressure measurements or evaluate other clinically relevant factors such as admission threshold for acute hypertension. However, in clinical practice, it is uncommon to assign a primary diagnosis of acute hypertension for a hospitalization in absence of elevated blood pressure. It is also possible that changes in ICD coding practices could have affected our results, but there is no obvious reason for increased coding of admissions owing to hypertension aside from an actual increase in patients. Third, we defined hospitalization for hypertension emergencies on the basis of primary discharge diagnosis and this will likely lead to underestimation of the number of hospitalizations because some patients may have a secondary diagnosis for hypertension emergency. Fourth, this study only examined hospitalizations and did not include emergency department visits and outpatient visits. Because a substantial proportion of patients with acute severe hypertension were managed in emergency department visits,[4–6] our study is likely to underestimate the total medical needs of acute hypertension. Fifth, we could not show what accounted for the changes in 30-day outcomes after hospitalization for acute hypertension because of limited data available in the administrative claims database. Last, there is no ethnicity information in the Medicare data. Given that the race variable in the Medicare enrollment database is known to undercount Hispanic and other racial subgroups, our analysis of these subgroups may underestimate the hospitalization rate of acute hypertension.[49,50]

Conclusions

Among Medicare fee-for-service beneficiaries age 65 years or older, hospitalization rates for acute hypertension increased significantly from 1999 to 2019. Black beneficiaries had the largest increase in hospitalization rates for acute hypertension across all age, sex, race, and dual-eligible strata. There was significant national variation, with the highest hospitalization rates generally in the South.

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Disclosures

Supplemental Materials

Data Supplement Figures I–IV
Data Supplement Tables I–VI

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